Remote Sensing
Another Point of View

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California I/M Review Committee Meeting

Presentation Outline

- Benefits of identifying on-road high emitters
- Fleet Coverage
- RSD program operating costs
- Looking forward

Benefits of identifying on-road high emitters

- Does Smog Check leave any high emitters on-road?
- Does RSD identify high emitters?
- What happens to identified high emitters?
- What's in the VID?
- How should benefits be calculated?

Benefits of identifying on-road high emitters

Does Smog Check leave any on-road high emitters: **YES**

- **ARB 2004 Evaluation of Smog Check:**

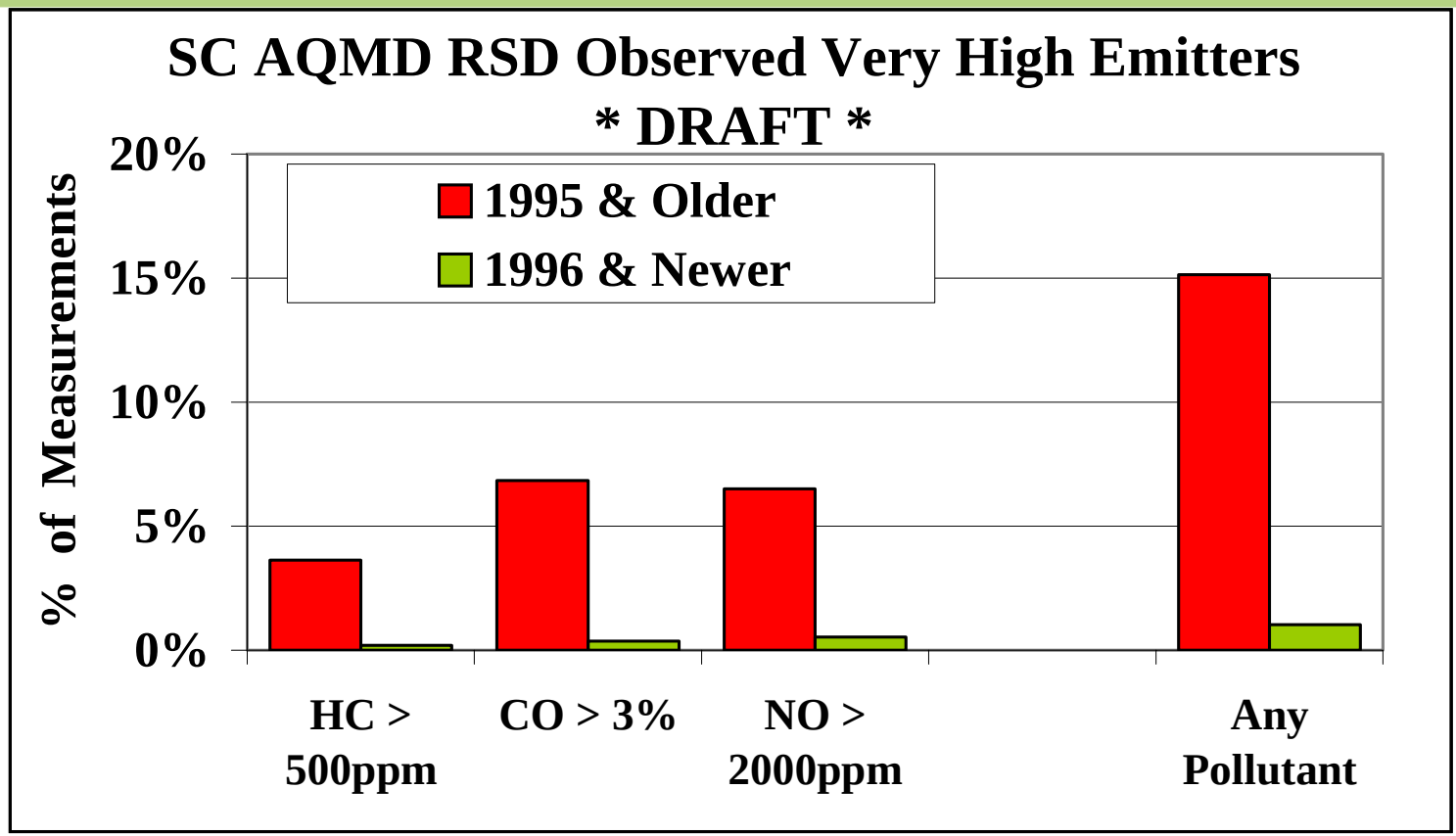
  "**40.4 percent of** the **repaired** vehicles tested **failed** the subsequent **roadside** test."

- **October 2006 IMRC Presentation, Phil Heirigs (draft):**

  40% of repaired vehicles **fail roadside ASM** soon after Smog Check;
  18% of passing vehicles **fail roadside ASM** soon after Smog Check;

More failing vehicles on road after Smog Check than fail Smog Check

Benefits of identifying on-road high emitters



Feb-May 2007:

- 15% of 1995 & Older
- 1% of 1996 & Newer

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Benefits of identifying on-road high emitters

Can RSD identify on-road high emitters? YES

Studies with Confirmatory Roadside Pull Over Tests

1989 Lynwood:

86% of vehicles with RSD >2% CO failed roadside inspection

1996 Orange County SCAQMD/DRI:

95% of vehicles with RSD >4% CO or 1,000 ppm HC failed IM240

2001 BAR:

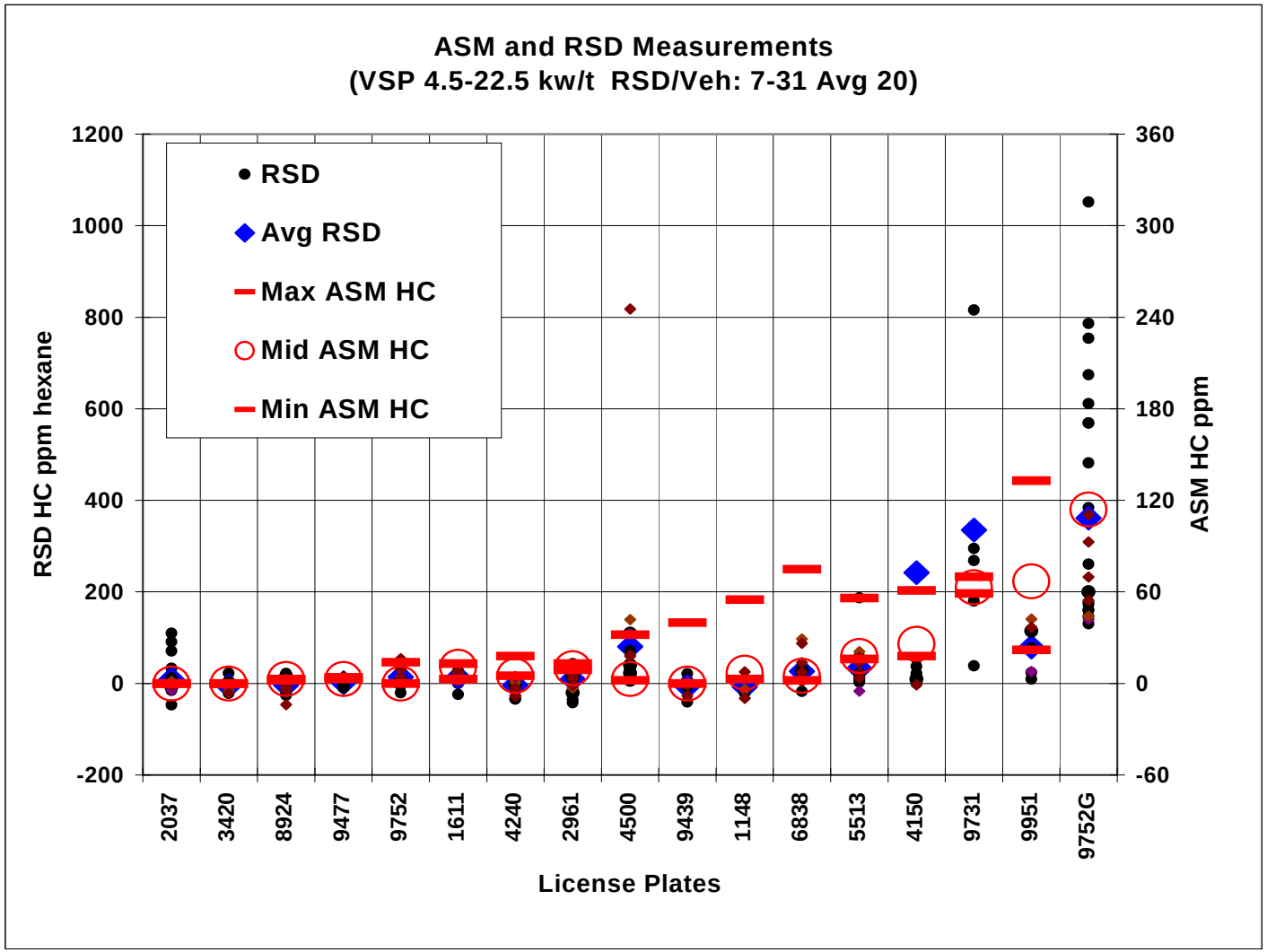
83-88% of vehicles with RSD >2% CO or 1000ppm HC or 1,500 ppm NOx failed roadside ASM

92% w/ 2 observations with RSD >2% CO or 1000ppm HC or 1,500 ppm NOx failed ASM

2004 ARB/BAR:

"For some vehicles, RSD cutpoints can **perfectly predict ASM failure** (i.e. approximately the **highest 3%** of RSD readings). ERG, 2006 CRC

Benefits of identifying on-road high emitters



~20 RSD passes at different modes

3 ASM tests

Don't expect 100% at ASM Cutpoints but good agreement for dirtiest vehicles

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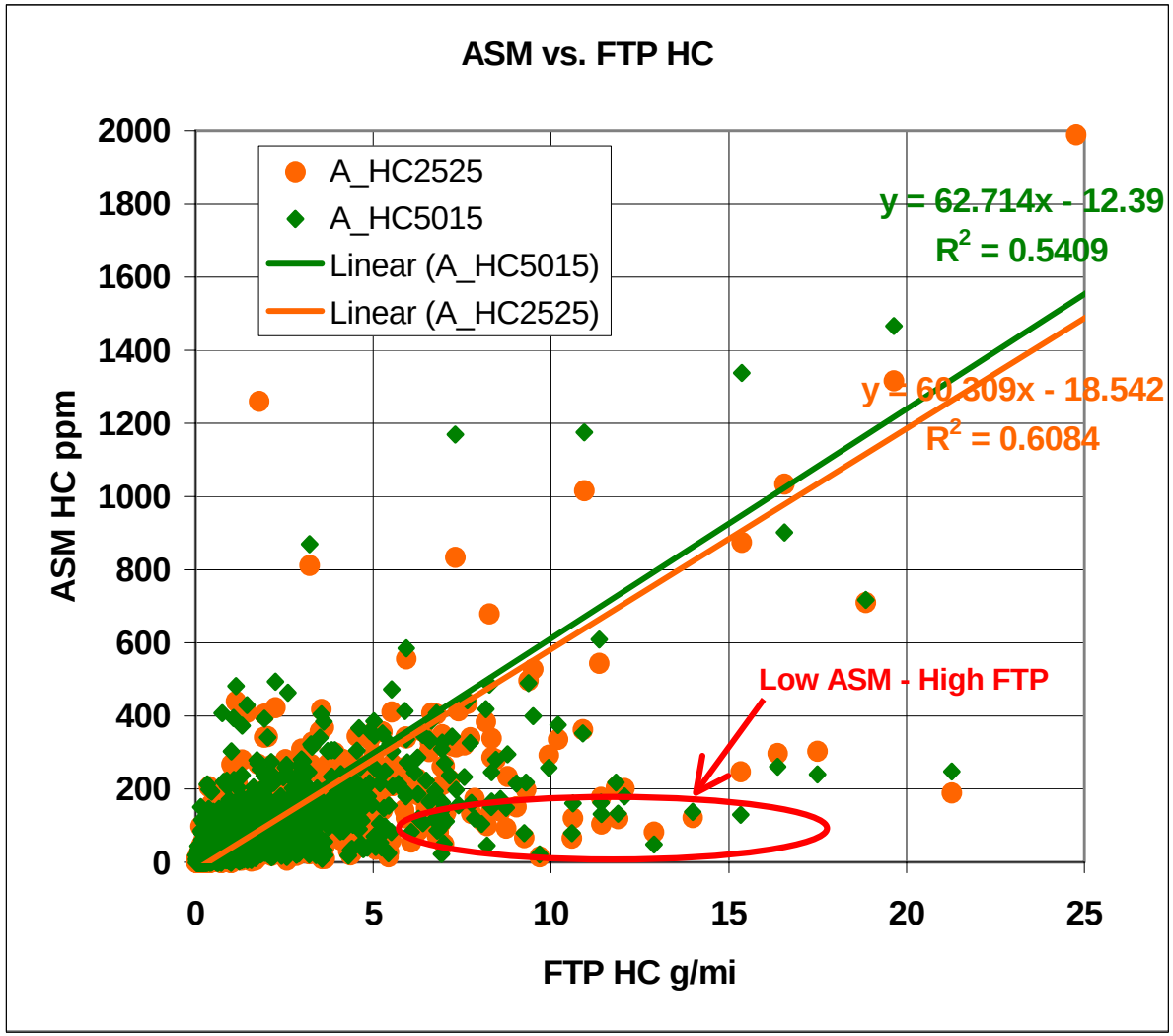
Benefits of identifying on-road high emitters



ARB/BAR FTP-ASM Dataset ~ 2,000 Vehicles (some off-chart)

ASM is not a perfect test.

Some high emitters have low HC on ASM

Benefits of identifying on-road high emitters

RSD identified high emitter behavior is similar to ASM identified high emitter behavior

Smog Test At:	Smog Test Fail % for High Emitters		Source
	5% Identified by RSD	Identified by ASM	
Pull-over	85-100%	100%	1
Voluntary Referee	?	85%	2
Smog Check Station	44%	42%	3,4

Sources:

1. RSD rate from various pull-over studies cited in earlier slide
2. ASM rate from ERG Remote Sensing draft Table 9-5
3. ERG Remote Sensing draft, Executive Summary, page 1-6.
4. ERG Remote Sensing draft Table 9-6

2,3,4 *ERG, Evaluation of Remote Sensing for Improving California's Smog Check Program Version 11 May 4, 2007*

Benefits of identifying on-road high emitters

Virginia Sample **Courtesy of Rich Olin, VA DEQ**	**Vehicles**	**Known Outcome %**	**% With Emissions Reduction**	
Notices due to be completed	**122**			
- No referral test:				
- Sell or scrap	**21**	**21%**	**21%**	
- Not subject to program	**2**	**2%**		
- Mis-register (GVWR, location)	**?**			
- Referral test:				
- Pre-inspection repair, or	**38**	**38%**	**32%**	?*
- Not an ASM high emitter				
- Fail and repair/scrap	**40**	**40%**	**40%**	
- Referral test fail %	***51%***			
Subtotal outcomes known	**101**		**92%**	
Return to sender	**8**		**TBD**	
Fine paid or action pending	**13**		**TBD**	

* Assumes 85% correct fail rate (phone survey in progress)

Benefits of identifying on-road high emitters

High emitter program referral options

- **Some on-road high emitters already beat Smog Check!**

- **Make sure a thorough inspection results in proper repairs**:
  - Diagnose vehicles – even if pass ASM
  - Visual and evaporative inspections
  - Documented repairs
  - VAVR and VRV options
  - Monitor results and follow-up

Benefits of identifying on-road high emitters

- **What's in the VID and what's not?**

  Missing data, good data and misinformation

  - **Missing pre-inspection repairs**
  - **Missing results for sold or scrapped**
  - **Clean vehicle cold starts**
  - **Excessive pre-conditioning, aborts**
  - **Vehicles tuned to ASM**
  - **Improper testing**

- **How to gauge the extent of problems:**
  - **Use Random Roadside ASM and RSD**
  - **Examine regional and local differences**

Benefits of identifying on-road high emitters

How to calculate benefits?

	?*
➢ Sell or scrap: Carl Moyer VAVR	+100%
• Missing from VID	
➢ Referral test and after repair:	
• Use appropriate ASM-FTP	+50%
• Use appropriate VMT	+10%
➢ Pre-inspection repairs:	+80%
• Missing from VID	
➢ Use realistic repair benefit life	+50%
• Consider Smog Check effectiveness on these vehicles	
➢ Include high emitters < 6yrs old	+15%
➢ Include smokers, PM	+15%

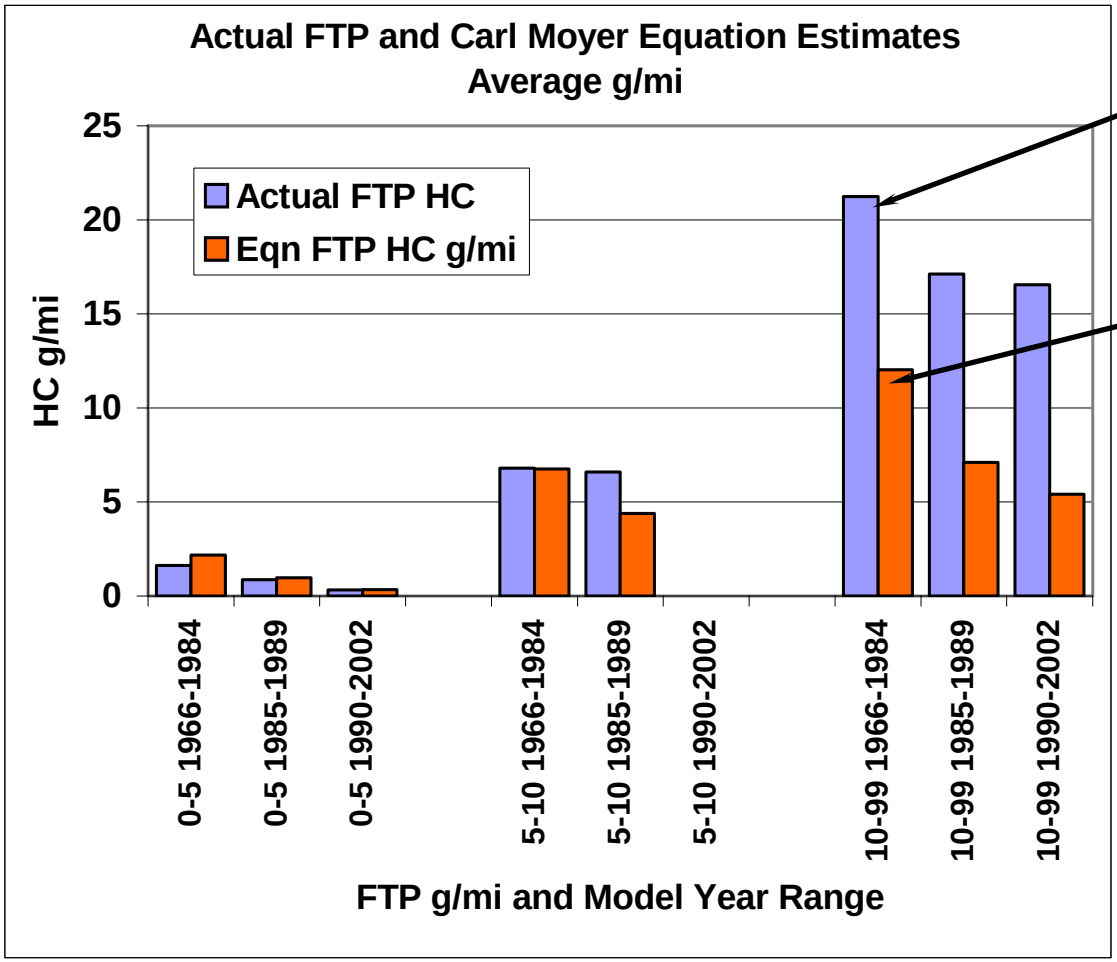
➢ Benefits are substantial, guess 3-10X estimated

*? WAG Increases over draft report – some are multipliers

Benefits of identifying on-road high emitters

- **ASM–FTP: Existing equations underestimate highest emitters**

FTP HC g/mi



Actual

Projected

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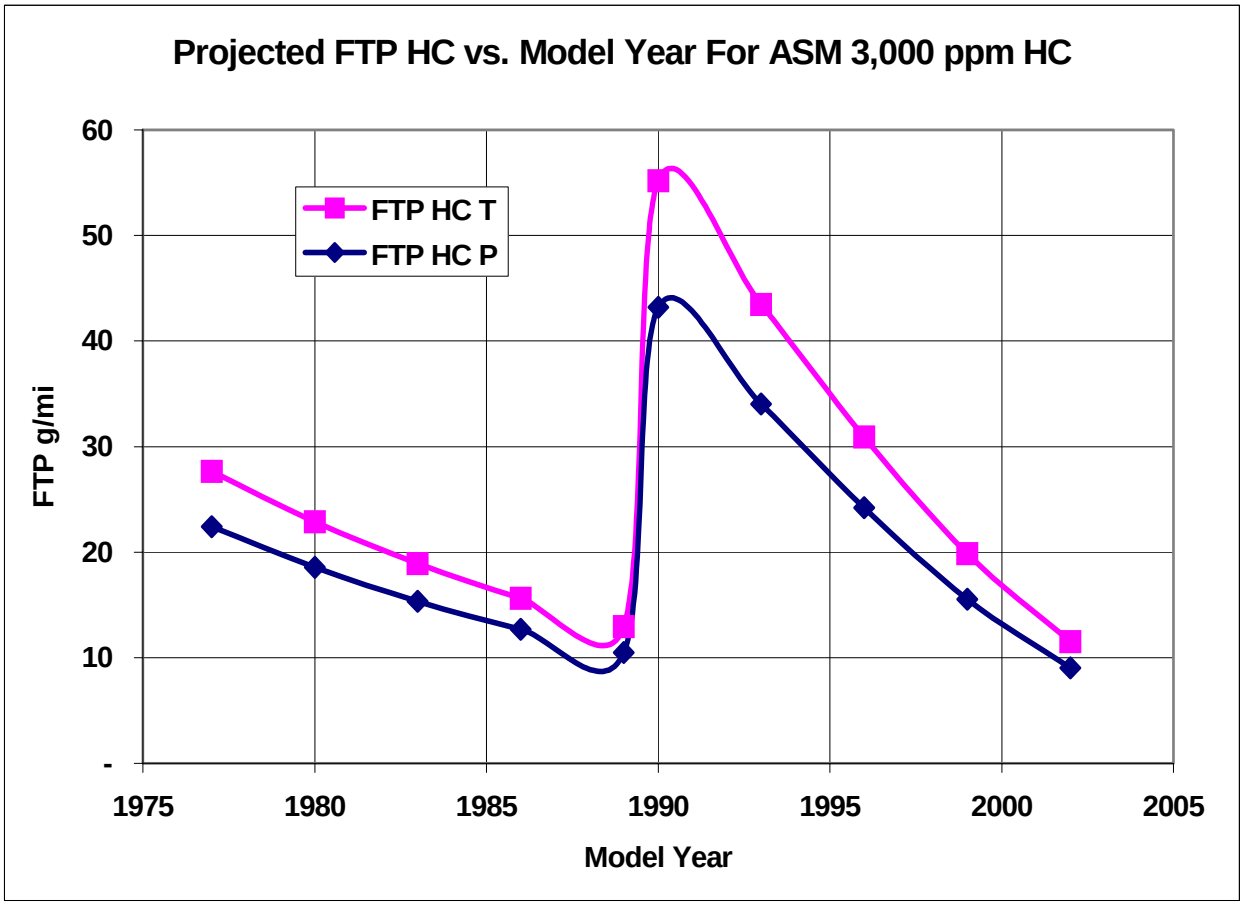
Benefits of identifying on-road high emitters

ASM – FTP: Existing equations MY discontinuity for HC

Projected FTP Emissions of 1975-2003 models with ASM 3,000 ppm HC

FTP HC g/mi



Benefits of identifying on-road high emitters

Behavioral benefits for Smog Check:

- Deter tampering or replacement of parts for I/M test
- Deter improper inspections
- Deter non-compliance
- Encourage prompt maintenance
- Encourage complete repairs
- Encourage correct registration (~3.5% unregistered[1])

1 Younglove T, et al, "Unregistration Rates for On-road Vehicles in California", Journal of Transportation and Statistics V7, 2004

Estimate benefits using combination of:

- VID data
- Random roadside
- RSD observations
- Special Surveys
- Track changes over time

Presentation Outline

- Benefits of identifying on-road high emitters
- **Fleet Coverage**
- RSD program operating costs
- Looking forward

Fleet Coverage

- **2002 St. Louis ~1.3M Vehicles, 4-5 RSD Vans**
  Gateway Clean Air Program:
  - Two years exempt
  - **Design goal 25%** RSD clean screen to reduce overall fee
  - **RSD vans <u>reduced</u>** as operational efficiency improved
  - **% of I/M vehicles measured** **51%**
    - **Est'd % of I/M vehicle VMT** **56 %**
  - **% of vehicles w six years exempt** **46%**
    - **Est'd % of I/M vehicle VMT** **51%**

- **Draft Report** Table 1-1:% of Statewide I/M Fleet 17% ?!

Assumed only 40% of vehicles in reasonable power range

Different divisor than the assumed RSD monitoring area

Fleet Coverage

- Operating Mode / Vehicle Specific Power (VSP)

Draft Report % of Vehicles in Reasonable Power Range:

- **Page 9-19** ***In this study, we found that about 40% of the any-VSP RSD readings were taken when VSPs were in the moderate load range of 5 to 20 kW/Mg*** **40%**
- Appendix B ***In this study, we chose to use RSD measurements that have a VSP range of 5 to 25 kW/Mg. For all sites in Sacramento, about 44% of the vehicles drove past RSD sites in this VSP range.*** **44%**
- **Table 6-2** + Valid RSD measurements 1,456,27
  + Moderate engine load (**5 < VSP < 25** kW/Mg) 843,867 **58%?**

ESP Programs:

- **Virginia 2005** (**3 < VSP < 22** kW/t) **80%**
- **Missouri 2002** (**5 < VSP < 25** kW/t)
  - **Measurements** **82%**
  - **Vehicles (majority w multiple measurements)** **93%**

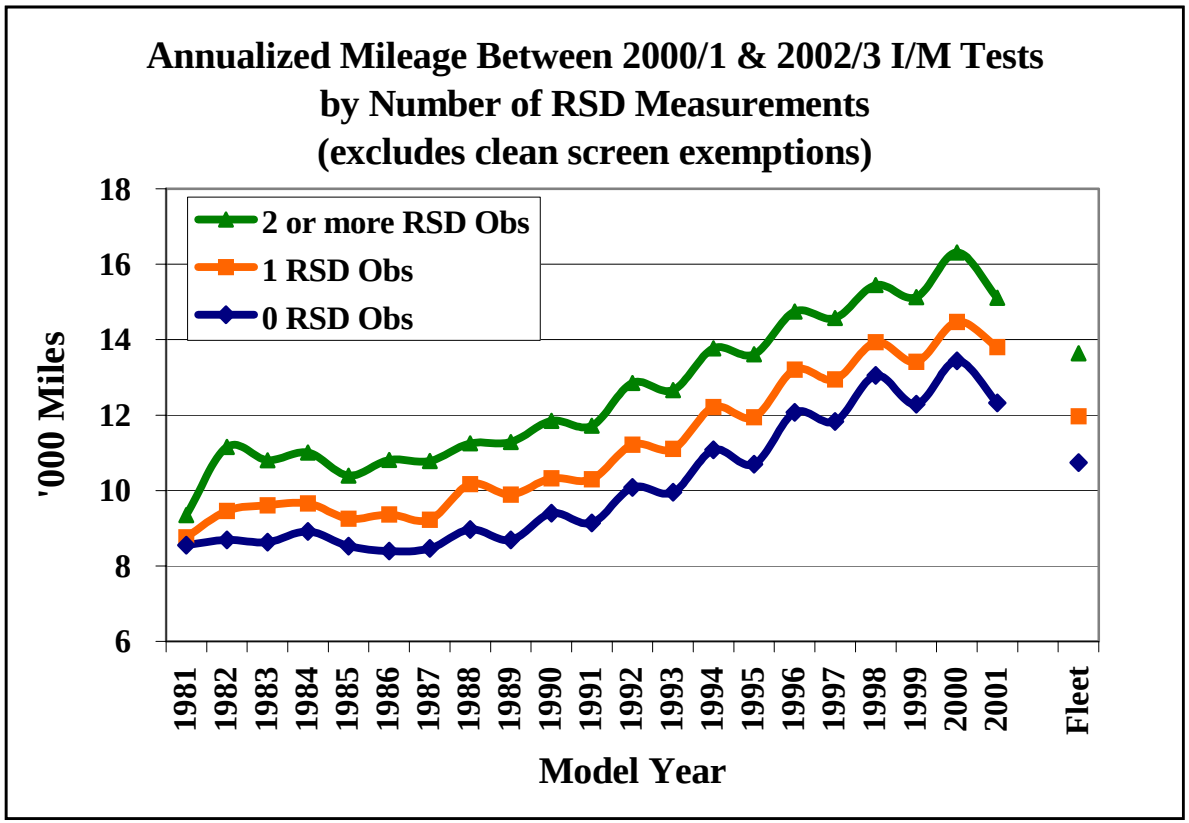
Fleet Coverage

- In-state License Plate to DMV Match Rates:
  - Normally in the 90-98% range

- Sites in Southern California
  - Metered ramps work well - best when the meter is on

Fleet Coverage

- VMT is more important than Vehicles
- Vehicles measured by RSD have higher VMT
- RSD high emitter VMT TBD – may be higher



Applied Analysis

Fleet Coverage

- Cost Effective Measurement of of Over 50% of Vehicles Has Been Achieved Without Difficulty
- Higher %'s Are Certainly Possible
- Ultimate % Limits Have Yet to be Tested

Presentation Outline

- Benefits of identifying on-road high emitters
- Fleet Coverage
- **RSD program operating costs**
- Looking forward

RSD Operating Costs per Vehicle

- Measure unique vehicles — **$1.08 - $2.50**
  - **SC AQMD** 10% coverage — **$1.25**
  - **Virginia** VSP qualified, 10% coverage — **$1.08**
  - **Texas** 20% coverage — **$1.60**
  - **Missouri** 50% coverage — **~$2.50**
  - **Draft report** Table 1-3 cost / Table 1-1 VSP qualified — **$10.82 - $17.47**
    7-10X?
- Clean Screen
  - **Missouri** 50% coverage w admin — **$10 - $15**
  - 2 yr exempt
  - **Draft report** Table 1-3 large program — **$145**
  - 6 yr exempt

10X?

RSD Operating Costs per Vehicle

- Voluntary High Emitter VAVR
  - **SC AQMD Dirtiest 3%@ 10% coverage** — **$320**
  - •20% recruitment
  - •$220 - RSD identification ($1.25/ 3% fail /20%)
  - •$100 - Recruitment, testing, processing

  Draft report Table 1-3 cost / Table 1-4 Vehicles — **$894 - $4,610**
  - **•$16M funding**

  3 - 15X?
- Mandatory High Emitter Call-in — **~$155**
- Smog Check Average High Emitter — **$337**
  - •2005: $49 fee / 14.5% fail rate

RSD Operating Costs per Ton

- **AQMD High Emitter VAVR/VRV:**
  - AQMD estimate:
  - VAVR **$8,000-$14,000** per ton (HC + NOx)
  - VRV **$12,000** per ton (HC+NOx)
  - ESP combined estimate **$6,000 - $12,000**

- **ValleyCAN Tune-In and Tune-Up**
  - Doug Lawson **$8,700-$14,900** per ton
  - Not including evaporative reduction benefits

- **Mandatory High Emitter estimate <$5,000** per ton
  - More efficient 'recruitment'
  - 'Free' sale or scrap

Presentation Outline

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- RSD program operating costs
- **Looking forward**

Looking Forward

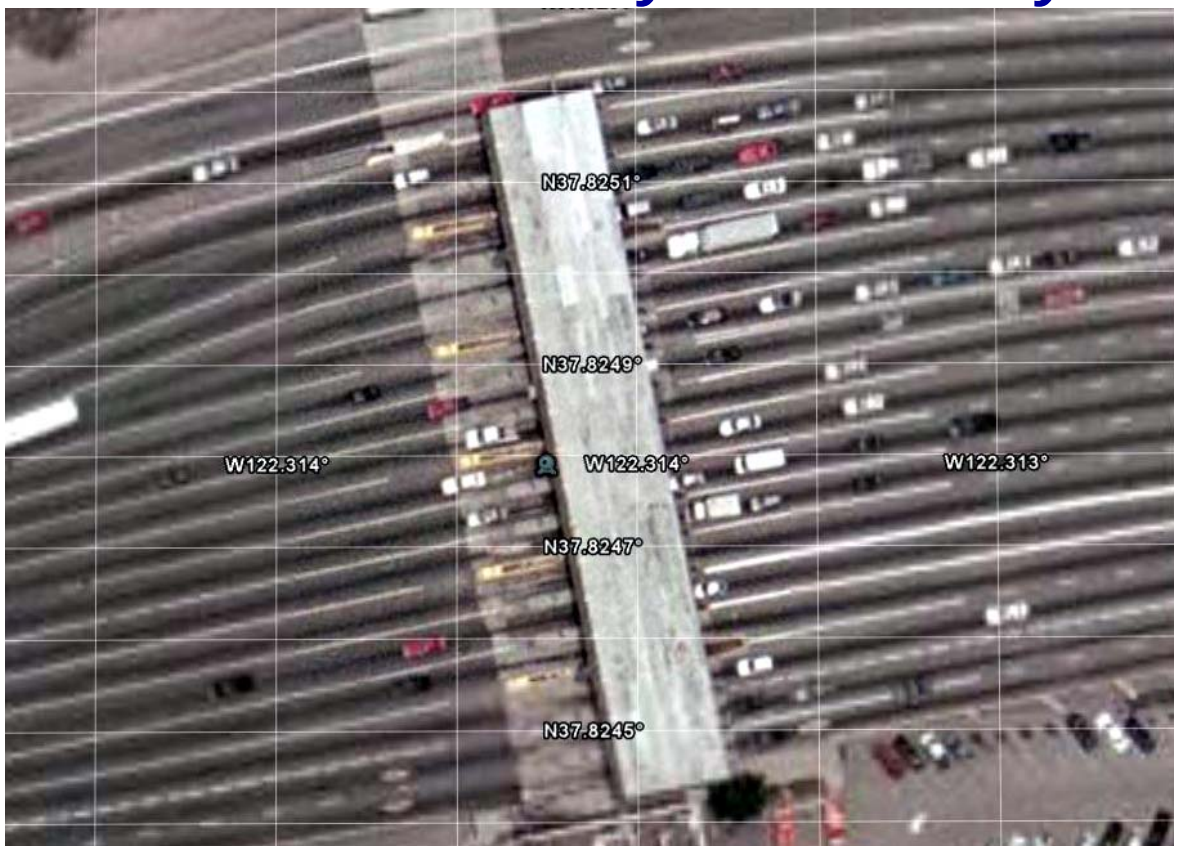
- RSD improvements:
  - Unattended units
  - Two-lane operation with proximity detection
  - Special opportunities
- Lower operating costs
- More productive locations

Looking Forward

- San Francisco Bay Area:
  - 4.5M Vehicles
  - Seven toll bridges
  - 800,000 vehicles per day
  - Approx. 60 toll plaza lanes
  - Special lanes for HD trucks & buses

Looking Forward

- San Francisco Bay Area: Bay Bridge



270,000 vehicles / day

Crying out for a pilot program!

Looking Forward

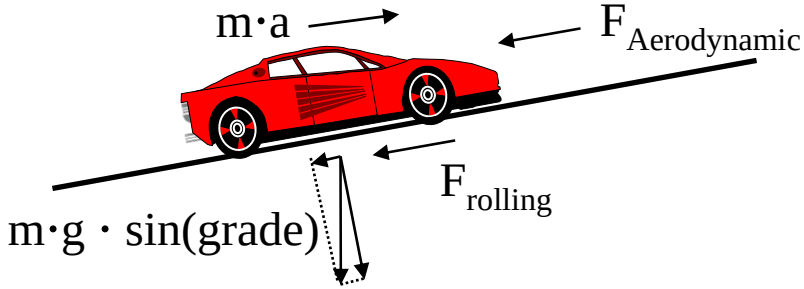
- Perfect set-up for RSD High Emitter:
  - ‘Stop and go’ or ‘slow and go’ traffic
  - Space behind toll booths
  - Lighting and power for 24x7 operation
  - Existing cameras and ALPR
  - FastTrac identifies 40-50% of traffic
  - Limited wider lanes for HD ideal for truck and bus monitoring
  - Could rotate RSD units between lanes
- Multiple annual measurements on vast majority of vehicles in the region
- Need only process high emitter plates

Conclusion

- RSD high emitter identification programs can cost effectively increase Smog Check benefits.

SPARE SLIDES

Vehicle Specific Power (VSP)



$$VSP = \frac{Power}{Mass} = \frac{\frac{d}{dt}(E_{Kinetic} + E_{Potential}) + F_{Rolling} \cdot v + F_{Aerodynamic} \cdot v + F_{internal\ friction} \cdot v}{m} =$$

$$\approx v \cdot a \cdot (1 + \varepsilon_i) + g \cdot grade \cdot v + g \cdot C_R \cdot v + \frac{1}{2} \rho_a C_D \frac{A}{m} (v + v_w)^2 \cdot v + C_{if} \cdot v =$$

$$\approx 1.1 \cdot v \cdot a + 9.81 \cdot grade + 0.213 \cdot v + 0.000305 \cdot (v + v_w)^2 \cdot v$$

Previous Work:

- Specific Power = $2 \cdot v \cdot a$ (EPA, 1993)
- Positive Kinetic Energy = $\Sigma\ pos(SP_i) / \Sigma\ distance$ (Watson et al., 1983)
- DPWRSUM = $\Sigma\ |SP_i - SP_{i-1}|$ (Webster and Shih, 1996)

Fleet Coverage

- Operating Mode / Vehicle Specific Power (VSP)
  - VSP = Engine Power Out / Vehicle Weight (kw/t)
  - Emissions more representative when engine is delivering moderate power
  - Example sedan full power (133hp, 2t) ~50 kw/t
  - FTP / IM240 maximum 23 kw/t
  - ASM 2525 and 5015 5-7 kw/t
  - RSD typical distribution 0-30 kw/t, avg. 10-15 kw/t

  - Draft report uses ranges of 5-20 kw/t and 5-25 kw/t

Fleet Coverage

- Operating Mode / Vehicle Specific Power (VSP)
  - Importance of VSP depends on application
  - Newer vehicles (~1991 and newer) better controlled over wider range of VSP – most vehicles
  - Application of VSP filter to Missouri results made no difference to clean screen effectiveness
  - Variation of emissions with power much less than difference between normal and gross emitters

Benefits of identifying on-road high emitters

Andrew Burnette, ERG 2006 CRC, Impact of VSP Filtering on RSD Prediction of Roadside ASM Failure:

Fail Rate Comparison Graph

RASM and Voluntary results agree with each other, but disagree with Mandatory results for older vehicles.